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AUTHOR Erdmann, M. H.; And Others
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ABSTRACT

This manual is intended to assist pesticide applicators to meet the requirements for certification under the Michigan Pesticide Control Act of 1976. The primary focus of this publication is on field crop pest control. The five sections presented describe: (1) Field crop pests; (2) Using pesticides in field crops; (3) Weed pests of field crops; (4) Disease control for field crops; and (5) Insect pests of field crops. A list of self-help questions and instructions for completing the questions are presented at the end of each section. (HM)

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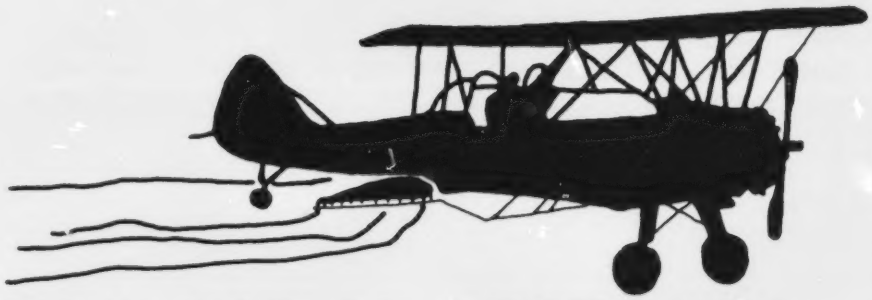
Field Crop Pest Control



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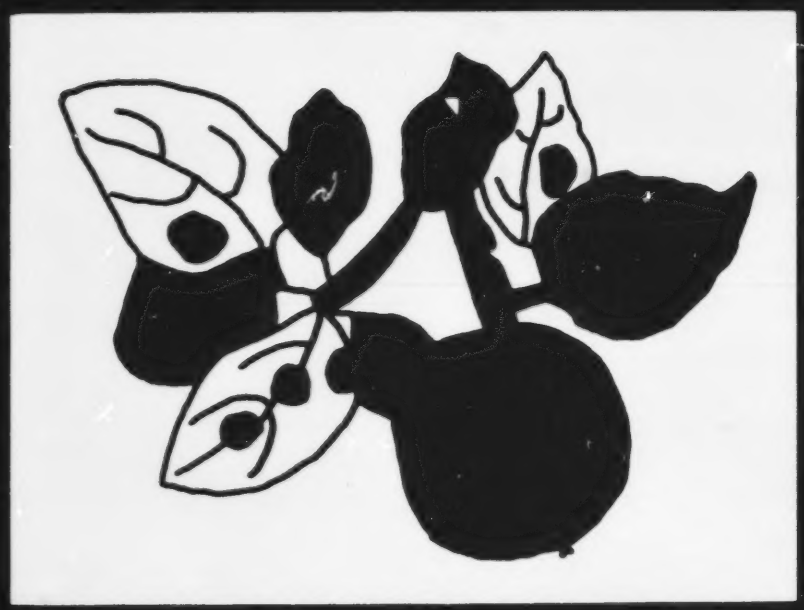

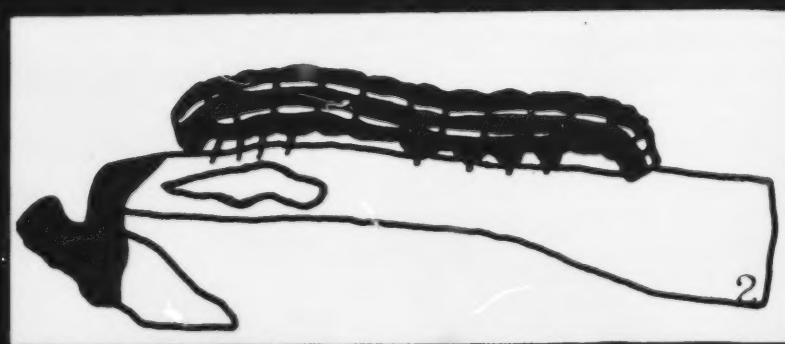

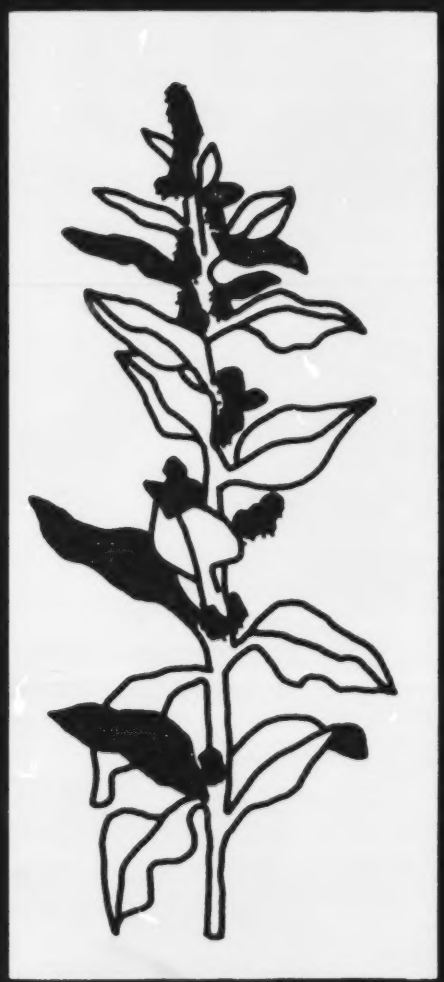

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PREFACE

This manual is intended to assist pesticide applicators to meet the requirements for certification under the Michigan Pesticide Control Act of 1976. The manual was prepared by M. H. Erdmann, F. F. Laemmlen, and R. F. Ruppel of Michigan State University.

A list of self-help questions and instructions for completing the questions are at the end of each section. If you encounter difficulties in using the manual, please consult your county agricultural extension agent or representative of the Michigan Department of Agriculture for assistance.

Some suggestions on studying the manual are:

1. Find a place and time for study where you will not be disturbed.
2. Read the entire manual through once to understand the scope and form of presentation of the material.
3. Then study one section of the manual at a time. You may want to underline important points in the manual or take written notes as you study the section.
4. Answer, in writing, the self-help questions at the end of each section. Instructions on how to use the self-help questions in your study are included with the questions. These questions are intended to aid you in your study and to help you evaluate your knowledge of the subject. As such, they are an important part of your study.
5. Reread the entire manual once again when you have finished studying all of its nine sections. Review with care any sections that you feel you do not fully understand.

This manual is intended to help you use pesticides effectively and safely when they are needed. We hope that you will review it occasionally to keep the material fresh in your mind.

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FIELD CROP PESTS

Over half of Michigan's farm income is derived from dairy and other livestock. This makes feeds and forages of special importance among field crops. Corn for grain or silage, not surprisingly, is first in acreage and value among crops in the state. Hay (alfalfa, clover, grasses, and trefoil) is second to corn, and oats, while lower in acreage, is the most widely planted crop in the state. Feed barley acreage is small, but important on some operations, and we even have a few fields of speltz. Sorghum, Sudan, and other grass forages have never been widely planted. The use of sorghum has been increasing in the past few years, however, in some southern counties.

Much of Michigan's crops, including feed grains and some hay, is sold off the farm. Wheat is the biggest of these cash crops. Soft white winter wheat is the type most widely planted. There is some soft red winter wheat and even a very small acreage of spring wheat. Soybeans in the southern counties, and dry beans (especially the familiar white navy bean) and sugarbeets in the Thumb and Saginaw Valley are very important to the state's economy. Malting barley, rye, mint, popcorn, and cloverseed are grown as special crops and there are scattered fields of buckwheat and sunflowers.

The diversity of the crops reflects the diversity of Michigan's soils and climates. Glaciers that once covered the state and left a bewildering mosaic of varying depths of variable soil materials behind as they retreated caused the variability of our soils. Michigan is located in the center of the North American land mass. This gives us a highly changeable continental climate. The Great Lakes, also relics of the glaciers, that surround us with their waters modifies the severity of the weather. Crops can be extended northward along the lakes in Michigan.

Field crops are planted everywhere in the state. Most of the state's agriculture, however, is located in the southern half of the lower peninsula. This is also the area of greatest population and industry. One result of this has been that a major share of our field crops, especially cash crops, are produced by part-time farmers who also work in industry. Further complications are the important water resources and tourist-recreation industry in the state. The tourist industry, along with the general public, is very much concerned with pollution-free surroundings, and especially clean water. We must be sure that our crop protection measures do not contribute to pollution here in Michigan.

Michigan has about 6.5 million acres of field crops. These are produced on about 70,000 farms distributed over the state. The diversity of crops, soils, weather, and farm operations, together with the mixture of agriculture with population, industry, and tourism makes pest control in our field crops complex. We must protect our crops from the pests. But, we must fit our control measures to the specific operations and surroundings if we are to achieve the maximum effectiveness with the maximum safety.

CROP PROTECTION

There is also a diversity of pests that can reduce yields and quality of our field crops. Weeds, diseases, nematodes, birds, slugs, and insects all attack these crops. These can be found in nearly all of our fields every year. Field crops are usually vigorous enough to tolerate some damage from these pests. Superficial damage or the presence of the pests themselves on the crop can be tolerated in field crops much more than in fruits or vegetables, for examples. The pests are of importance only when they threaten to lower the yield or quality enough to justify their control.

The point at which the numbers of a pest are large enough to be considered a threat is called the "economic level." This level will change with each pest and crop. It will also change with stage of crop growth, weather, and with the importance of the crop to the individual farm operation. The idea of crop protection is to keep the pest numbers below this economic level. We do not need to eliminate all of the pests; just to keep them at less than this damaging number.

Some pests, especially insects and diseases, can increase rapidly with weather that is favorable to them. We must stay constantly alert of the pests if we are to control them satisfactorily. To do this we must know:

- how to identify the pests and their damage;
- when they need control; that is, to know the economic level for that pest;
- the stages of development of the pest most susceptible to control and the time of year or stage of crop growth that the susceptible pest stages occur;
- the methods that are best for their control under these specific circumstances.

Information on pests and their control is available from the variety of sources; books, magazines, and even pesticide company brochures. Your County Agricultural Extension Agent can help you both by supplying literature as well as by identifying and advising on the control of the pests. Experience is still the best teacher. The pests are usually always present in small numbers in our fields and need control during some years in our own or in nearby fields. Time spent to actually see the pest and various means of controlling it in the field is a good investment.

We need this knowledge of the pest to enable us to obtain good control. Of equal importance is our need to keep informed of the pests in our own fields; what they are, where they are, and whether they need control or not. Alerts of the general threat of pests can be received from the County Agricultural Extension Agents. Pests, and especially weeds, rarely threaten every field in an area. We must check our own fields regularly for the pests; this is the only way that we will know if they threaten our own fields. A good practice is to check for the pests every time that you go through your fields. Remember that crop protection means <u>preventing</u> damage. We must stay alert to the pests that damage our crops and control them <u>before</u> the damage is done.

METHODS OF CROP PROTECTION

There is no single best method for protecting crops from pests. That is especially true with the diversity of crops, pests, and all that we have in Michigan. Crop protection should be considered an integral part of the overall farm operation. This is obvious for weed control in field crops, but is also true for all of the other pests. Crop protection methods have been divided in

to classes, such as biological or chemical controls, and we will so discuss them here. Pest control specialist recently have been integrating these separate methods with overall farm operations into a total program for crop protection. This "pest management" approach has been started here in Michigan, and you will hear more about it as the work progresses.

While we do not think of them as such, legal controls contribute to the protection of our crops. Quarantines that prevent the introduction of new pests are especially important. We become aware of their importance, however, only when some foreign pests, such as the cereal leaf beetle or alfalfa weevil, slip through to plague us. Seed certification programs that assure us of seed free of diseases, such as bacterial blight of beans, also contribute to clean fields. Pesticide regulations such as those forbiding the use of volatile weed killers near sensitive crops also help in keeping our crops safe.

There are a variety of cultural controls, usually simple good farming practices, that aid in suppressing pests. Good drainage, land leveling, seed, fertilization, and planting that will give vigorous plants that can tolerate some pest damage as well as give us increased yields. Sound rotation of crops can also reduce or even eliminate some pests. A four year rotation of sugarbeets with other clean cultivated crops will reduce the problem with sugarbeet cyst nematode, for example.

Some farm operations are altered specifically to control pests. The most obvious of these is cultivation to control weeds in our fields. The planting of wheat after the Hessian fly-free date (that is, after the flies cease activity in the fall) practically eliminates the Hessian fly as a pest. Have you thought of drying grains for storage as a pest control measure? It is. Drying grains prevents growth of molds and reduces the dangers of insect attack. Cutting of alfalfa in the early flowering stage is practiced as a means of reducing alfalfa weevil losses on many farms.

Many pests survive or hide in plant debris, weedy spots, or trash and other places and serve as "seed" populations for these pests. Sanitation, keeping the area clean, is a good means of reducing such pests. Stored grain insects are notorious for increasing in trash, old stocks of grain, or even bags of old seed and then infesting the new grain brought to the storage area. Weedy margins of fields or weed patches in the field are sources of weed pests and can harbor

plant diseases or insects. Stalk rots of corn are carried over winter on stubble left in the field. In all of these cases and many more, reasonable sanitation can reduce our problems with the pests.

Not all varieties of a crop are equally susceptible to damage by pests. The use of less susceptible, or resistant, varieties is an excellent means of reducing pest damage. The recent outbreak of southern corn leaf blight was brought about by an intensive planting of susceptible corns, and was controlled by returning to more resistant hybrids. Resistant varieties for many plant diseases have been developed and disease control in many field crops is based on their use. Resistance to some insects, while not as common as for diseases, is also known. Most of our better corn hybrids have resistance to the first generation European corn borer built into them, for example. It makes good sense to use a resistant, rather than a susceptible, variety whenever practical. Your seedsman or County Agricultural Extension Agent can help you pick resistant varieties for your use.

Pests are strongly influenced by the weather, other organisms, and other elements in their surroundings. The pest can increase rapidly when the conditions are right and barely survive under adverse conditions. Moisture is needed before spores of some fungus diseases are released, for example, and a dry spell at the critical time for spore release can cause a complete control of the disease caused by the fungus. Natural enemies of insect pests (their predators, parasites, and diseases) can also keep the insects at less than damaging numbers. These environmental, or natural, controls are not manipulated by man, but they are extremely important in determining the severity of our pests.

While we cannot control the weather, we can manipulate the organisms in our fields to increase their efficiency in crop protection. This is called biological control and is important with insect pests. Wasp-like parasites of the alfalfa weevil and cereal leaf beetle have been brought from Europe, the homeland of the pests, and released here in Michigan. The parasites have established themselves and, with care in managing, should reduce these pests to non-damaging levels in the near future. We will see more use of biological controls as the pest management approach to crop protection is developed.

Legal, cultural, natural, and biological controls and the use of resistant varieties and sanitation practices should be our first line of defense against pests. It simply makes good sense to make use of these control measures to reduce

pest problems with little additional costs or effort. Their use, alone or in combination, will depend on our special situation. We should consider them as carefully as we do our other farm operations and make them a part of our routine practices where they will fit.

Chemical controls: the use of pesticides to protect our crops, is our final alternative for crop protection. The use of pesticides is being roundly criticized as endangering man and his environment. There is a base for part of this criticism and regulations, such as that requiring certification of all users of the more hazardous pesticides, are being tightened to reduce the hazards associated with pesticide use. Pesticides are readily adaptable to many situations, predictable in their results, and often the only control measure known for many pests. Weeds can be controlled by cultivation rather than weed killers, for example, but the costs in labor and machinery make cultivation practically unthinkable in many crops.

Pesticides are widely used in field crops. They are of great benefit, but their use must be well planned and carefully done for complete effectiveness and safety. The points to consider in planning for protection of field crops are outlined in this manual. The discussion is of a general nature and no attempt is made to cover the many special situations caused by our diverse conditions. You are urged to analyze your own special operation, surroundings, and pests and select the program that will be most satisfactory for you.

SELF-HELP QUESTIONS

Now that you have studied this section, answer the following questions. Write the answers with pencil without referring back to the text. When you are satisfied with your written answers, see if they are correct by checking them with the text. Erase your answer and write in the correct answer if your first answer is wrong. Note that these questions are not necessarily those that are used in the certification examination.

1. What are some of Michigan's principle field crops?

2. Why are Michigan's soils so variable?

3. How does the tourist industry affect pest control in field crops?

4. What is the "economic level" of a pest?

5. What are some sources of information on pests and their control?

6. How can we know what pests threaten our own fields?

7. Name some types of legal controls of pests.

8. Name some cultural controls for field crop pests.

9. How can sanitation reduce pest problems?

10. Where can you obtain information on varieties of crops that are resistant to pests?

11. What is meant by biological control?

12. Why are chemicals used to control pests?

USING PESTICIDES IN FIELD CROPS

Selecting the Pesticide

The first step in chemical control is always to identify the pest. When the pest is known, the next step is to select the pesticide to be used in its control. Pesticides are often highly selective. A pesticide may be excellent for controlling one pest, but may be ineffectual against even a second, closely related pest. Be sure of the exact identification, and then be sure that the pesticide you choose will control that pest.

Your County Agricultural Extension Agent or pesticide dealer can advise you on the pest's identification and available pesticides for its control. The label of the pesticide that you will use should be checked, however, to be sure that the specific pesticide is registered for use against that specific pest in the specific crop that you will need.

The label will also give the amount of the pesticide and the time and number of times that the pesticide can be applied. These points should be followed exactly to avoid underdosing with resulting poor control, overdosing with the chance of leaving an excess residue on the crop, or applying at a time when the pesticide is ineffective or damaging to the crop.

The precautions given on the label should also be carefully read. They will give you instructions on any danger of injuring the crop, phytotoxicity, and how it can be avoided. They will also indicate mixtures with other chemicals or pesticides that are effective (compatible) and mixtures that should be avoided. Some pesticides will leave a residue (or "carryover") in the soil that could injure subsequent crops. The label instructions will indicate the crops that can be safely planted if danger of soil residue exists.

The diversity of agriculture in Michigan puts some constraints on the pesticides that can be employed. You should consider the rotation practice in

the field to be sprayed and the surroundings of the field before selecting the pesticide. Highly toxic materials must be avoided in areas near homes where people could be exposed to them. Persistent materials that could contaminate our waters or leave residues in the soil that could interfere with later crops should be avoided whenever possible. Honeybees are very important as pollinators of Michigan's crops. Pesticides should be used with special care to avoid endangering our honeybees.

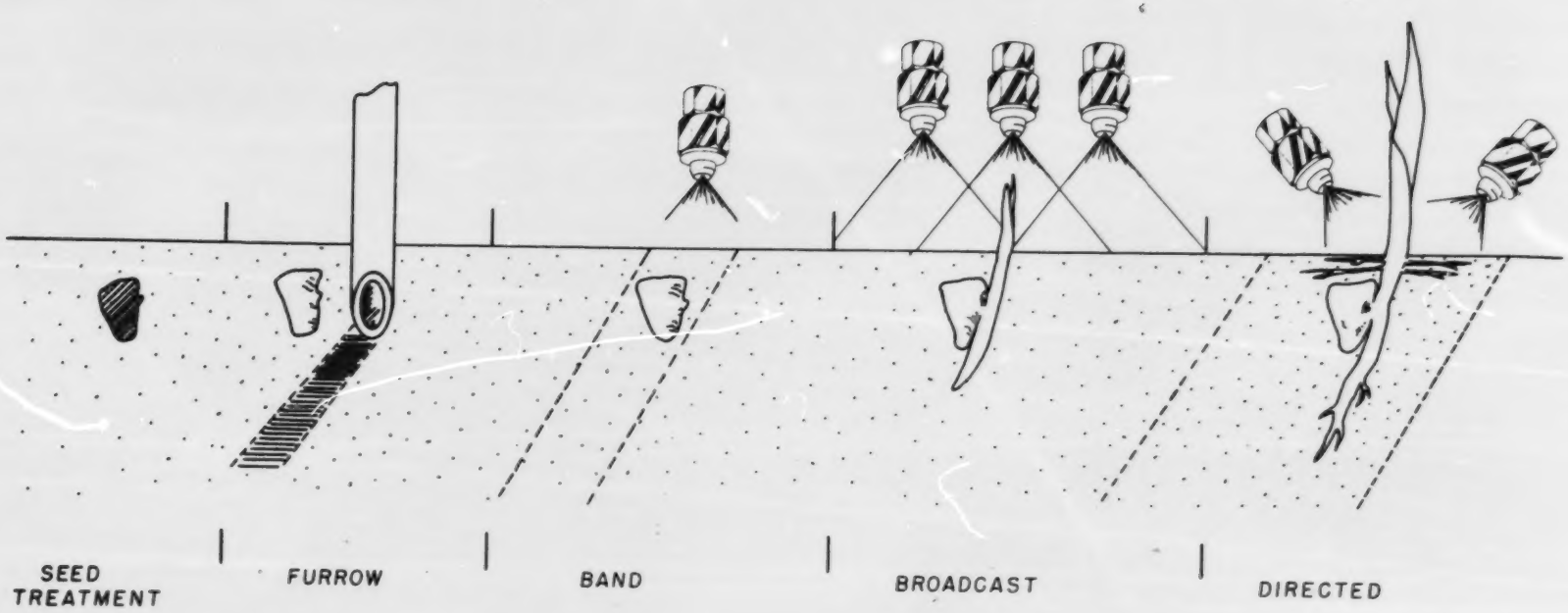
Equipment and Application

The formulation of the pesticide used and the type of application will determine the equipment needed for application. Not all formulations can be mixed with water for spraying. Be sure that the formulation that you buy is the proper one for your use. Check the instructions on the label to be sure that you have the proper equipment for the specific use intended.

There are several common types of applications used in field crops:

- Seed treatment—pesticides applied to the seed to protect the seed or seedling from pests.
- In-furrow applications—pesticides applied as a narrow row into the soil through a hollow shank.
- Band application—pesticides applied only over the row leaving some space between the rows untreated.
- Directed application—pesticides applied only to one area of the crop; this is done to avoid injuring the crop or to concentrate the pesticide on the area infested by the pest.
- Spot applications—pesticides applied only to areas of the field infested by the pest.
- Broadcast applications—pesticides applied to cover the entire field.

Coverage, the density and distribution of the pesticide after application, is very important in pest control. Coarse granules that leave large spaces


SEED TREATMENT
FURROW
BAND
BROADCAST
DIRECTED

between them are adequate for control of some insects, such as cutworms, that move extensively. Full coverage that leaves nearly an uninterrupted cover of pesticide may be needed for other pests. Coverage with sprays is determined by droplet size and the amount of finished spray applied per acre. Fine droplets applied at high rates will give the most complete coverage, while coarse droplets at low rates will give more scattered coverage. The pesticide must be applied to the proper place to control the pest. Drops, extensions hanging down from the boom to place the nozzles to the side of the plants, may be needed to assure coverage of the underside of the leaves for the control of certain pests.

One of the most important factors in the effective use of pesticides is accurate calibration—determining the amount of spray material applied per acre. A range of 15 to 60 gallons per acre at a pressure of 20 to 60 pounds per square inch is satisfactory for most field crops. Adjust the boom height and nozzle spacing so that the spray is applied where it should be. For broadcast spraying using 80 degree nozzles, the nozzles are placed about 18 to 20 inches apart on the boom and 18 to 20 inches from the sprayed surface. A good way to calibrate a sprayer is to:

- Fill the spray tank with water only.
- Spray a measured area, in a field if possible, at a fixed tractor-speed and pressure-gauge setting. Be sure to allow for partial coverage if bands are used.
- Measure the amount of water needed to refill the tank.
- Divide this amount by the fraction of an acre sprayed to get the gallons applied per acre.
- Mix the amount of chemical desired per acre with water to give this much spray material.

For example, if ten gallons were applied on one-fourth acre, the volume of spray material applied would be 40 gallons per acre. Check the actual gallonage applied frequently as you spray to be sure of your calibration. If you change the tractor speed or pressure setting, nozzle size or number of nozzles, the amount of liquid applied per acre will be different and recalibration will be necessary.

The pesticides are commonly applied at several different times in field crops:

- Seed treatment—applied before planting as slurries or dust or applied at planting as planter-box treatments.
- Pre-plant application—applied to the soil before planting; pre-plant applications may require incorporation into the soil before planting or be simply left on the soil surface.
- Planting application—applying to the soil at planting time; planting time pesticides may require some incorporation or covering following application, or simply be left on the surface of the soil.
- Pre-emergence applications—applying to the soil after planting but before the seedlings have emerged from the soil.
- Post-emergence (or foliage) application—applying to the plants or as directed sprays around the plants after they have emerged.

The optimum time to apply the pesticides will depend on the pest, the crop, and the weather. Many pests are susceptible only at certain stages of their development. Many fungal diseases can be controlled, for example, only as their spores are germinating. This means that the fungicide must be on the leaf before the spore arrives. Similarly, boring insects must be killed before they reach the security from contact with the insecticide within the stalk or leaf. Be sure that you understand the life cycles of the pest and know when the most susceptible stages will be present so that you can properly time your application. Timing can be critical for the control of many pests.

Weather can affect the pesticide, the pest, and the crop. Some weed killers are effective only if soil moisture is sufficiently high to allow weed seed germination shortly after the herbicide is applied. Cool weather can reduce the activity of insects and, thus, their contact with insecticides. The presence of free water as dew or rain is needed for the germination of some disease spores. Heat and high moisture can cause volatization or decomposition of some pesticides and high winds can cause poor coverage or drift of the pesticide out of the field. Your knowledge of the factors influencing the effectiveness of the pesticide should be used in determining when they should be applied.

Safety with Pesticides

All of the safety precautions used with pesticides should also be used with field crop pesticides. The large acreage involved, the wide distribution of field crops, and their common use as animal feeds presents some special problems with their safety.

The use of pesticides in field crops is not as intensive as in fruit or vegetable crops. Nearly all field crops are treated at least once with pesticides (predominately with weed killers), however. The large area in field crops means that a large volume of pesticides are used and a large segment of our agricultural land is exposed to pesticides. Field crops are also grown everywhere in the state, including the forest-recreational areas in the north and the highly populated area of the south. We have a diverse agriculture interspersed with housing developments, industry, and forests. These points make the threat of hazard and pollution from pesticides very great if they are not used safely by everyone. We can reduce the hazards from pesticides by using every care in their application. The best rule to follow is: Do not apply the pesticide if there is any question as to its safety to man or the environment.

The recent problem with PBB has made us acutely aware of the real damage that contamination of livestock feed can do. The greatest care must be taken in selecting the pesticide, in applying the proper amount, and in allowing sufficient time between application and harvest to avoid any possibility of excessive residues of the pesticides in our feeds. Be sure to read the label before applying any pesticide and be especially sure if it will be applied wherever livestock feed could be exposed.

SELF-HELP QUESTIONS

Now that you have studied this section, answer the following questions. Write the answers with pencil without referring back to the text. When you are satisfied with your written answers, see if they are correct by checking them with the text. Erase your answer and write in the correct answer if your first answer is wrong. Note that these questions are not necessarily those that are used in the certification examination.

1. What is the first step in the chemical control of a pest?

2. What does phytotoxicity mean?

3. What is meant by a directed spray of a pesticide?

4. What determines the coverage obtained with a spray of pesticide?

5. What is meant by calibration?

6. What is meant by a pre-emergence application?

7. Why is an understanding of the life cycle of a pest important in its control?

8. How can we, as applicators, reduce the hazards of pesticides?

WEED PESTS OF FIELD CROPS

Why Control Weeds?

WEEDS REDUCE FIELD CROP YIELDS by competing for water, nutrients and light. Some weeds release toxins that inhibit crop growth, and others may harbor insects, diseases, or nematodes that attack crops. Weeds may interfere with harvesting operations, and in some instances, contamination with weed seeds or other plant parts may render a crop unfit for market. It is obvious that profitable crop production depends on effective weed control.

You should never attempt to establish a field crop in a field that is badly infested with perennial weeds such as quackgrass, yellow nutsedge, or Canada thistle. Herbicides and tillage should be used to control these pests at least one year in advance.

Usually, effective weed control in field crops requires a combination of management techniques. You may need to use a combination of different herbicides or alternative methods. In some cases, minimizing tillage can effectively reduce weed populations. Growing the same crop year after year, and using the same weed control techniques will encourage the development of problem weeds. Rotation of crops, herbicide or tillage methods can help solve this problem. Whenever you see a small infestation of a problem perennial weed invading a field, it should be eradicated immediately. Wherever possible, weeds should be prevented from producing seed. One plant can produce thousands of seeds, and these seeds will live in the soil for many years.

Types of Weed Pests

Weeds may be classified according to their life cycles, habits of growth, or general appearance of their leaves and stems.

Annual weeds are plants which complete their life cycle from seed to seed in one year. If they germinate in the spring, grow, mature, and produce seed that summer they are called summer annuals. Examples are large crabgrass and redroot pigweed. Plants that germinate in late summer, overwinter, and produce seed the next spring are called winter annuals. Examples of winter annuals are common chickweed and shepherdspurse.

Annual weeds reproduce primarily by seed. Single plants of some species may produce hundreds of thousands of seeds per year. Only a small percentage of these seeds germinate the next season but many more seeds can remain viable in the soil for a period of several years. Annual weeds should be controlled when they are small and whenever possible, seed production should be prevented.

Biennials are plants which complete their life cycle in two years. They typically have a juvenile stage the first season and then produce a seed stalk the second year. Examples of biennials are white cockle and wild carrot.

Perennials are plants which live for more than two seasons. They are often grouped into two categories according to their reproductive mechanisms.

(1) "Simple" perennials reproduce primarily by seed and may possess thick fleshy roots capable of regenerating a plant; however, unless they are mechanically cut or disturbed they do not generally reproduce from roots. Plantain and common dandelion are examples of this group.

(2) "Creeping" perennials are those which commonly reproduce from creeping vegetative organs. These may be aboveground (stolons) or underground (rhizomes) rootstocks as in quackgrass and field bindweed. Perennials such as nutsedge and Jerusalem artichoke also reproduce by tubers (underground swollen stems) whereas wild garlic can reproduce by bulbs in the soil and small bulblets produced on top of the plant.

Creeping perennials and those possessing tubers are the most difficult perennial weeds to control. Cultivation and other mechanical means of control can result in increased populations due to propagation by these vegetative organs.

More details on perennial weeds including color pictures and descriptions of 40 common species are available in Extension Bulletin 791.

Weeds may also be designated as broadleaved species or grasses. This is usually done because herbicides are often toxic to one type and not the other. Weeds which have succulent stems are called herbaceous weeds. Those with hard stems that resemble vines, trees or shrubs are classified as woody plants. Poison ivy, Virginia creeper and dewberries are examples of woody perennial weeds.

Principles of herbicide use: Herbicides are used either on the foliage of weeds or through the soil to kill germinating weed seeds. Some chemicals have both foliar and soil activity.

Foliage Applications

These treatments are made to leaves of growing plants, usually as liquid sprays. They kill plants by two methods—contact or translocation.

Contact treatment kills only the plant parts actually contacted by the herbicide. However, the noncontacted parts (i.e., roots) may die because they are deprived of the leaves. Adequate distribution of the herbicide over the foliage is essential. Selectivity may depend upon arrangement and angle of leaves, differential wetting, location of growing points, or upon spray placement. Contact herbicides are most useful to control seedlings. An example of nonselective contact herbicide is paraquat.

Translocation kills the entire plant because the herbicide moves within the plant. For example, when applied to the leaves the herbicide is translocated to the roots. It may also move from older leaves to young growing points. Therefore, herbicides of this type are used on perennial plants as well as annuals. For example, 2,4-D is a translocated herbicide that is widely used to kill emerged broadleaved weeds in corn.

With foliar herbicides, many factors influence the movement into the plant and the responses can vary. More consistent results are obtained and variability may be explained if these factors are known.

Proper application: Rate and concentration of herbicides are important and therefore uniform application and proper choice of gallonage is necessary. Although uniform distribution of systemic-type herbicides is not as critical as for soil applications, too high a rate can cause decreased long-term kill. Uniformity of concentration and delivery rate is essential; therefore, correct nozzles, sprayer speed, agitation, pressure and dilution are important.

Interception by leaves: Leaf angle, degree of hairiness, expansion, and leaf area-dry weight ratio influence response. In annuals, greatest concentration per unit area of dry weight is obtained in seedling stage. In perennials, the greatest ratio occurs later so treatment should be delayed until considerable growth has developed. A canopy of leaves can be a deterrent to effective control or a safeguard against injury. Wetting conditions will affect interception by changing leaf orientation and reducing leaf area.

Retention: Keeping spray droplets on the leaf is an important consideration once contact with the leaf has been made. Type of leaf surface such as waxy coating, pubescence, and roughness affect retention. Retention can be increased by use of wetting agents and other materials that lower surface tension, nonpolar formulations (esters) and low spray volumes.

Rainfall will cause run-off if it occurs shortly after or during application. With many herbicides, one to two hours after application without rain will allow for penetration. Herbicides also volatilize from leaf surfaces when exposed to high temperatures.

Absorption: This phenomenon varies with each herbicide, formulation, plant species, and environmental factor. Thickness of the cuticle (waxy coating) has a direct relationship. Uniform leaf coverage is essential for maximum penetration. Penetration may be both an active and a passive process. High humidity, high soil moisture and conditions that favor rapid growth increase absorption. Stomata that are open may be an avenue of entry for volatile herbicides and those of low surface tension.

Translocation: Downward movement is through the phloem (living tissue) and is favored by production of assimilatory material and growth processes. Herbicides tend to move to regions of activity such as buds, young leaves, seed, storage

organs and meristematic areas. Excessive application rates or contact injury reduce translocation and are factors to consider in herbicide combination. In a few cases, herbicides have recycled in a plant. Movement out of the plant roots or excretion of herbicides have been shown under certain conditions. This will reduce the amount available to the plant and plant responses will be altered accordingly.

Activation and deactivation: Some herbicides (2,4-DB) are activated by an enzyme system after entering the plant (B-oxidation) while others (atrazine in corn) are deactivated by being metabolized or complexed with cell constituents such that they are not available to exert phytotoxicity. The rate or degree of degradation is influenced by conditions affecting plant growth, i.e., temperature, sunlight, soil moisture.

Accumulation: The rate of absorption and translocation affect accumulation. Accumulation at the sites of action, generally meristematic regions, varies with species and rate of degradation at these sites. Environmental factors that influence metabolism and other mechanisms at the site of action will influence plant response.

Cellular sensitivity: Ultimate response of a plant to a herbicide is at the cellular level. Susceptibility varies during the season and with the season. Maturing plants develop varying levels of tolerance. Mature tissues or those of low metabolic activity will show little response to a concentration that would have been injurious at an earlier stage of growth.

Soil Applications

These treatments are usually applied to the surface of the soil but may also be incorporated into the soil by cultivation, or injected below the soil surface.

Timing of the application in relation to the growth stage of the weeds and crop is important. The application may be made preplant, preemergence or post-emergence as related to the growth stage of the crop plant.

Surface moisture must follow surface treatment for most soil-applied herbicides to be effective; you will obtain best results when these herbicides are carried into the soil by rainfall, or overhead irrigation.

The tolerance of vegetable crops to some soil-applied herbicides depends to some extent on keeping the herbicide placed in the surface half-inch of soil. If there is excessive leaching of the herbicide into the termination zone, injury can result. For this reason, less herbicide should be used on coarse-textured sandy soils that are low in organic matter or clay content. It also takes less herbicide to control weeds on these soils because they are not readily tied up.

Before using a herbicide, be familiar with its residual life in the soil. Some herbicides may persist in the soil for extended periods, which will influence other cropping plans the same season or the next season.

Herbicide applications may be further defined based on the area treated. Applications over an entire area of foliage or soil are termed broadcast applications. In contrast, applications in a strip along a row of plants are called band applications. Sprays that are aimed at the base of plants and kept off the foliage are called directed sprays. When localized weeds or clumps of weeds are sprayed with a hand sprayer this is termed "spot" spraying.

Many factors may have an effect on how well soil-applied herbicides move to the site of action. A knowledge of these factors involved in the transfer of a herbicide from applicator, through the soil, and to the plant is helpful in obtaining more consistent responses or in explaining some of the variability.

Proper application: The use of the correct rate of application is essential. Very small amounts are necessary to inhibit plant growth. However, sufficiently high rates must be used to compensate for the amount bound to the soil or otherwise made unavailable for uptake by the plants. Rates must not be of the magnitude to cause crop injury or soil residues.

Uniformity of distribution over the sprayed surface is important. Nozzles must have a uniform delivery, a uniform spray pattern, even spacing and proper height to give uniform coverage. Water volume is not important if there is a constant concentration and uniform distribution. Constant pressure and speed are necessary. Granulars present a greater problem in obtaining uniformity.

Soil interception: An even, uniform surface, free of clods, manure, plant litter and other debris will help insure a good distribution pattern. Spray droplets cover the upper surfaces of clods, but not beneath, while granulars fall in depressions. Granular formulations again present a greater problem on uneven surfaces.

Physical movement: Wind and water (excessive rainfall) cause run-off or movement from treated area. Movement is to depressions, causing increased concentrations in these areas. Some leaching into the soil is necessary for effective control. Incorporation into the soil will benefit some herbicides but distribution may be uneven or placement too deep. Band applications are lost when untreated soil is moved in by the cultivator.

Volatility: This is a major form of loss for certain herbicides. High soil temperatures and air movement increases volatility losses. Damp or wet soil at time of application can cause additional losses through water vapor distillation or by keeping the herbicide concentrated in the exposed surface layer as water moves to the surface. Incorporation reduces volatility losses.

Photodecomposition: Many herbicides are broken down by exposure to sunlight. Losses occur when herbicides remain on the soil surface for extended periods.

Solubility: Movement into the soil is related to solubility; therefore, salts will move more readily than wettable powders. Additional rainfall is needed to get wettable powders into the upper one-fourth to one-half inch of soil.

Movement in soil: Water transport provides for the greatest amount of herbicide movement in the soil. This occurs primarily when there is sufficient water to exceed field capacity. Diffusion in soil water is important only in the vicinity of roots. Diffusion in soil gasses plays a part if the herbicide is quite volatile. Greatest movement is downward; however, some lateral and some upward movement occurs. Movement varies greatly in different soil types.

Degradation: Breakdown of the chemical is by chemical and biological processes. Temperature, aeration, pH and other soil factors will affect chemical processes such as hydrolysis and oxidation. The degradation by micro-organisms is one of the major means of herbicide loss from soil. Organisms may be specific for a particular herbicide and their numbers will increase when repeated applications are made. Conditions that favor growth of micro-organisms will speed breakdown.

Adsorption: A great deal of variability exists in the amount of herbicide adsorbed by soil since soils vary in organic matter and inorganic soil colloids. Organic matter adsorbs more strongly and thereby greatly reduces the

amount of chemical available and also retards movement in soil. Randox (CDAA) is an exception in that it is more effective in high organic matter soils.

Absorption: This is the means of entry into the plant and it is favored by conditions that favor high transpiration rates. The amount of root system exposed is important since amount of herbicide absorbed is generally proportional. A heavy plant population may reduce amount absorbed by any one plant as well as concentration of herbicide in soil.

Translocation: Upward movement is primarily in the xylem (nonliving tissue) and concentration is in areas of most rapid water loss. Rather high concentrations of herbicide can be moved since living tissue is not involved once the chemical reaches the vascular system.

Activation and Deactivation: Some herbicides (2,4-DB, Sesone) require activation either in the soil or plant. Other herbicides may be deactivated in the plant by metabolism or modification. Active and inactive metabolites or complexes may be formed. Selectivity may be obtained by these processes.

Accumulation: There is a threshold concentration for phytotoxicity. Amount taken in must be greater than the amount degraded or eliminated. Conditions that affect absorption, translocation or degradation will reduce the accumulation of toxic concentrations.

Cellular sensitivity: Plant response is due to sensitivity to a certain concentration of chemical. Species vary greatly in tissue structure. Environmental conditions and tissues' maturity play an important role. Mature tissue generally shows less activity and older plants are less likely to be killed.

Preventing Herbicide Injury

Although herbicides offer an effective and economical means of control, certain risks are inherent in their use. Plant injury is one of these risks. No plant is completely resistant to herbicide injury, but any plant tolerates certain dosages. Selectivity, or the ability of a herbicide to kill weeds without harming plants, may be partially lost under adverse environmental conditions. Careless application can also result in injury to a customer's plants or those of a neighbor. Injury can range from complete destruction of plants to slight stunting or discoloration which often has no long-term adverse effect. More details on

prevention and diagnosis of herbicide injury can be found in Extension Bulletin 809.

Make sure spray equipment is designed and operated properly: Faulty application equipment or improper use of equipment can lead to overdosing which causes crop injury or underdosing which gives poor weed control. Herbicide sprayers are designed to apply chemicals uniformly over a given surface area. Application rates are determined by the speed, pressure, nozzle size and the amount of chemical added to the diluent (usually water). Nozzles designed specifically for herbicide application (flat fan or even spray) should be used rather than cone-type nozzles used for other pesticides. Improper spacing of nozzles can cause overlapping and result in a banded injury pattern.

Equipment should be calibrated periodically to assure that the desired gallonage is being delivered. When nozzles become worn (particularly by abrasive wettable powders) the flowrate can increase and result in overdosing or uneven application.

Frequent checks on tractor speeds and line pressure during application will insure uniform application rates. Injury occurring on slopes could result from overdosing if the sprayer were slowed down as it climbs the hill.

Proper agitation in the spray tank is essential if uniform distribution is to be obtained. Failure of the agitation system can cause settling of the spray material, and overdosing may result in the areas that are first sprayed.

Cleaning weed control sprayers: It is important to keep weed control sprayers clean. This is especially true if you use them to spray more than one crop or to apply fungicides and insecticides.

Do not use a sprayer to apply either insecticides or fungicides if the sprayer has contained 2,4-D type herbicides.

When cleaning a sprayer, thoroughly rinse the whole sprayer with water, inside and out, including boom, hoses and nozzles, both before and after cleaning. Partially fill the sprayer with water before you add the cleaning agent. Keep the pump running so that the cleaning solution will circulate throughout the sprayer. Do not leave corrosive cleaning agents in the tank or spray system more than two hours.

When you are using only pre-emergence sprays, a good rinsing with water is enough. For other spraying purposes, remove weed killers from sprayers by adding 1 gallon of household ammonia or 5 pounds of sal soda to 100 gallons of water. Allow this solution to stand in the sprayer for at least two hours. Drain it out through the boom and nozzles, and rinse the sprayer with water. Do not let spray solutions stand in the tank overnight. Do not allow solutions to run into streams or other water sources.

SELF-HELP QUESTIONS

Now that you have studied this section, answer the following questions. Write the answers with pencil without referring back to the text. When you are satisfied with your written answers, see if they are correct by checking them with the text. Erase your answer and write in the correct answer if your first answer is wrong. Note that these questions are not necessarily those that are used in the certification examination.

1. Can minimizing tillage effectively reduce weed populations in some cases?

2. Explain difference between simple and creeping perennials.

3. What stage of plant are contact herbicides most useful in controlling?

4. Are translocated herbicides effective against both annuals and perennials?

5. What can result from too high a rate of herbicide?

6. List four factors influencing herbicide interception by leaves.

7. How can retention be increased?

8. Does thickness of the cuticle affect absorption?

9. Do translocated herbicides tend to move to the roots?

10. List three factors affecting the rate or degree of degradation of herbicides?

11. Does the rate of absorption affect accumulation?

12. Does water volume affect proper application if there is a constant concentration and uniform distribution?

13. What are band applications?

14. Is some leaching into the soil necessary for effective control when using soil applied herbicides?

15. What is photodecomposition?

16. Does any lateral movement of herbicides occur in the soil?

17. How does organic matter affect adsorption?

18. Can some herbicides be deactivated in the plant?

19. How do nature plants differ from young plants in sensitivity to herbicides?

20. What is herbicide selectivity?

DISEASE CONTROL FOR FIELD CROPS

Diseases in field crops are defined here as those which are caused by microorganisms classified in such broad groupings as fungi, bacteria, and viruses. These multiply in the crop and cause losses in quality and quantity. The method of control for each organism is determined by its cost,ease of application, and effectiveness. One or more methods of control may be used for a crop.

Breeding crop varieties for resistance to important diseases is a common method of disease control. Most of the preliminary work is done in laboratories, test plots, and by seed increase organizations. The finished product is then sold to the grower.

Chemical control is quicker and more flexible. The chemicals used are most frequently fungicides, although an occasional bactericide is available and no viricides are cleared for diseases of field crops. Most fungicides cannot penetrate the plant skin. Their effectiveness depends on their ability to prevent the fungus from entering the plant. A few fungicides are called systemics because they can penetrate the plant epidermis and inactivate the fungus which is inside the plant.

Seed treatment is an important method of disease control with fungicides. An effective fungicide intercepts the transfer of a fungus from one crop to the next via the seed. Fungicides can be applied during seed treatment to protect the young seedling and reduce seed decay from organisms which are in the soil. Seed treatment fungicides may be applied to the seed in liquid or dry form. The liquid form may be a true solution, wettable powder mixed with water or flowable form applied with slurry treater. The dry or dust application is a mechanical mixing or simply the dry fungicide is applied to the seed in the drill box or planter box. Dry methods can result in imperfect control because of incomplete coverage of the seed.

Applying a fungicide to the growing plant by spraying or other means, can reduce disease by preventing some of the fungi from entering. This method requires selecting an effective fungicide and getting thorough coverage at the proper time. Since there is new surface exposed during constant growth, repeat application is often necessary. This method is seldom used for field crops because it is not economical when there is a low gross per acre except in special circumstances.

Changing cultural practices is a practical method of disease control. Continuous culture with the same crop can result in a rapid buildup of a disease organism. Rotation with other crops slows down this buildup. The environment can favor an organism and hence result in more disease. Poor drainage and soil compaction favor certain soil-borne fungi. Improving soil drainage along with aeration and improving soil structure with proper tillage and organic matter can reduce injury from soil-borne fungi.

Several diseases in field crops are selected to illustrate types of diseases or methods of control for some of the more important diseases found in Michigan.

A. Loose smut in wheat is caused by a fungus with related forms attacking either barley or spelt. The fungus multiplies and produces black spores in such abundance as to completely replace the grains in the head. At blossoming time, these spores disperse to healthy flowers where each spore can germinate and penetrate into the growing embryo. Here the fungus remains dormant until the healthy looking seed is planted. The fungus "reawakens" and spreads in the plant until it reaches the flower head where it again produces its mass of spores. Most fungicides applied to diseased seed would not penetrate into the embryo to kill the fungus. However, a systemic fungicide like carboxin can penetrate the seed to inactivate the fungus thus rendering the seed safe for planting.

B. Loose smut in oats is quite different from the above because the black spores lodge on the outside of the seed. Here the fungus remains dormant until the seed is planted in the spring. Germination of spores is rapid and the young oat plant is invaded via the hypocotyl followed by rapid advancement up the plant until the head is reached. Here the seed is replaced with a mass of fungus spores. During threshing, the enveloping sac is broken and the spores scattered to healthy grains. Being on the surface of the seed, this fungus is easier to

control with fungicides. However, fungicides vary in effectiveness and the local county agricultural agent should be contacted for the most recent recommendations. Several varieties of oats have considerable field tolerance to loose smut and could be planted.

C. Commercial corn seed is fairly free of disease producing fungi. Nevertheless, if this seed is planted in soil below 55° F. followed by cool wet weather, then a number of fungi in the soil can attack the seed and the young seedling before emergence. A protectant broad spectrum fungicide is usually applied to the seed to reduce seed rot and increase emergence. As the young seedling grows from the vicinity of the seed, there is less influence from the seed fungicide.

D. Soybean seed is prone to invasion by a fungus which causes Phomopsis seed rot. Wet weather during delayed harvest permits rapid spread of this fungus from the seed pod into the seed coat. Several fungicides are marketed which are applied as blossoming begins which are said to reduce fungus invasion of the seed. In Michigan yield increases have not been demonstrated, although better seed may result, particularly in south Michigan. A closely related fungus causes pod and stem blight under much the same conditions. If there is premature senescence in the field and wet weather is anticipated, then the soybeans should be harvested as soon as possible.

E. Phytophthora root rots in alfalfa and soybeans are caused by a fungus. The alfalfa strain causes the most damage in wet soils. Soil fumigation with a fungicide is not practical so soil drainage improvement might be easier. Some commercial varieties are sold as resistant but these have not been tested thoroughly. The variety Iroquois has considerable tolerance. The Phytophthora in soybeans does the most damage under the same wet soil conditions. The Phytophthora in soybeans has developed seven difference races. Soybean seed sold in Michigan does not have resistance to more than one of these races. One or two long season varieties have shown some field tolerance. In addition, several other soil-borne fungi cause root rots. The farmer can try to reduce root rots by improving soil drainage, improving soil structure, practicing crop rotation, and reducing the spread of fungus on implements.

F. Wheat Spindle Streak Mosaic is caused by a soil-borne virus. Early spring yellowing of wheat is the first evidence of this virus disease. Short yellow-green dashes in the leaf may persist as long as the weather is somewhat cool. The virus is in the soil and enters through the roots. The most practical method of control is to select and plant varieties which show some tolerance to this virus disease. The new Tecumseh variety of winter soft white wheat is one variety adapted to Michigan conditions.

G. Bacterial Blight of Beans is a collective term used to describe the symptoms of one to several bacteria-caused diseases. The causal bacteria are carried on and in the bean seed from crop to crop. Individual infected seeds produce a diseased plant from which surrounding plants may be infected by bacteria spread on equipment or rain and wind. Blossoms and later pods become infected in which contaminated seed are produced. The only sure way to produce blight-free beans is to use certified seed which has been produced under dry disease-free conditions. Streptomycin sulfate used as a seed treatment helps reduce the incidence of blight by reducing external and internal seed infection, but it is not as certain a remedy as blight-free certified seed.

H. The sugarbeet cyst nematode (Hederodera schachtii) is a major problem in a limited area of sugarbeet production in Michigan. The adult female develops as she feeds on the surface of a root. When she matures she begins to lay eggs which are retained inside her body which literally becomes an "egg sac" or cyst. The eggs remain dormant in the cyst between crops. When a new crop is planted, substances produced by the plant root stimulate the eggs to hatch and the life cycle is completed. Crop rotation and the use of granular nematicides are the only economical method of cyst nematode control. Trap crops have been effectively used for cyst nematode control in other areas of the United States. A trap crop is one which provides the stimulus to cause egg hatching in the nematode, but does not provide the proper nutrients to allow the nematode to complete its development. For the sugarbeet cyst nematode, such crops include wheat, corn, and other grains, hence these crops are recommended as rotation crops with sugarbeets.

SELF-HELP QUESTIONS

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1. What is meant by a systemic fungicide?

2. What are some common methods of treating seeds with fungicides?

3. How does rotation affect the buildup of plant diseases?

4. Why must a systemic fungicide be used as a seed treatment against loose smut of wheat?

5. Where are the spores of loose smut of oats located on the seed?

6. Are fungi that attack corn seed more damaging during cool (less than 55^{o}F.) weather?

7. When should fungicides be applied for control of Phomopsis seed rot of soybeans?

8. What can be done to reduce damage from Phytophtora root rots?

9. Are wheat varieties resistant to wheat spindle streak mosaic available in Michigan?

10. What is the best way of avoiding problems with bacterial blight of beans?

11. Where are the eggs of the sugarbeet cyst nematode laid?

INSECT PESTS OF FIELD CROPS

There are a large number of species of insects and mites that can damage Michigan's field crops. Only a few of them, however, appear in damaging numbers in some fields each year, and even fewer of them are pests in large acreages of the state. While their damage is usually good from the standpoint that it is usually scattered and small, we tend to ignore the insects and sometimes are surprised by their outbreaks.

Insect control must be aimed at protecting the crop from the damage of the insects. This means that we must get to recognize the insects, check our fields for them regularly, and be prepared to treat them if they threaten our crops. Descriptions of the pests and their damage and suggestions on how to check your fields for them are given in extension bulletins. These are available from your County Agricultural Extension Agent. Your extension agent can also help you identify insects and select a control program for your crops.

Nearly all stages of all field crops are subject to insect attack. Examples of pests that can attack the different stages and parts of crops are given below. As noted, the insects are usually scattered and sporadic in their appearance in damaging numbers. Their actual appearance is difficult to predict. They frequently tend to be more abundant under some conditions than under others and these conditions are noted for each insect. Their control depends strongly on their biology. Some important biological features as they effect control are also noted.

Seed

The seedcorn maggot is a spindle-shaped, headless, legless worm that attacks seeds of corn, dry beans, and soybeans in the soil. The adult, an undistinguished looking fly, is attracted to organic matter in the soil to lay its eggs. The maggots that hatch from these eggs burrow into the germinating seed and weaken or kill the seed or seedling. Crops planted in soils high in organic matter (muck soils or soils that have much manure, stubble, or weeds plowed down in them) should be protected from the maggots. Seed treatment with an insecticide will control the maggot very effectively.

Seedling

Flea beetles are small, hard-shelled, very active insects that feed by chewing round holes through the leaves of many plants. When numerous, they can destroy the cotyledons of small sugarbeets and ruin stands. They are of special importance in corn as they spread the bacteria that cause Stewart's wilt disease. The adults overwinter near the crowns of grasses and feed early in the season on many crops. They lay their eggs in grasses and the larvae feed on the roots of grasses. Flea beetle damage is most common near grassy fields or in grassy areas of fields. These areas especially should be checked for the beetles and their damage starting with the first germination of the crop. The beetles are readily controlled with sprays of insecticides if they are abundant in the field.

Root

White grubs are large, thick, white larvae with a dark head and six small legs just behind the head. They are the young of the common May beetles or June bugs. The beetles lay their eggs in grassy sod. The grubs that hatch from these eggs usually feed for three years on the roots of the grasses. They will feed on almost any crop that is later planted in that field. Plow furrows should be checked for the grubs when fitting sod, old pasture, or other grassy fields. A soil insecticide should be broadcast and disced in to control the grubs before an infested field is planted.

Chewing

The armyworm is a cylindrical caterpillar with a definite head, six small legs just behind the head, and ten fleshy legs near the rear of the body. It is usually dark in color with a prominent light stripe along each side of its body. The armyworm is the larva of a drab colored moth. The moth lays its eggs in grasses small grains, corn, and occasionally other crops. There are three or more generations per year. The first generation is the most damaging to our crops. The armyworm feeds by chewing at night from the margins of the leaves. It usually remains at the bases of the plant during the day. It will feed on almost any crop, but it is most damaging in wheat and corn. We cannot predict outbreaks of the armyworm. Heavy stands of grasses or rye are favored areas for egg laying and these are checked for larvae starting early in the season. Alerts on the presence of the armyworms are sent to Count Agricultural Extension Agents.

Growers should check their own grasses, wheat, and corn for the pest when the alert is given. Look for the sawdust-like droppings of the worms and for the worms themselves near the bases of the plants. The armyworm can be controlled by ground or aerial applications of insecticides. It is extremely difficult to control when it is large. Check the fields frequently for this pest and apply the insecticide when the small larvae are easily found in the field.

Mining

The spinach leaf miner is a white, spindle-shaped, headless and legless maggot that causes light-colored, blotchy mines in the leaves of sugarbeets and other crops. The adult miner is a fly that lays elongate, white eggs in a semicircle on the underside of the leaves. The maggots that hatch from these eggs enter and feed between the upper and lower surfaces of the leaves. There are several generations per year with the first, and rarely the second, generation being a pest in sugarbeets. The later generations attack home garden vegetables, and the miner is most common in sugarbeet fields close to home sites. The underside of sugarbeet leaves should be checked for eggs starting early in the season. A spray of insecticide should be applied in fields where the eggs are common when the first small mines are seen. The miner will be protected from the spray after the maggot has entered the leaf. The spray must be properly timed to be effective.

Sucking

The potato leafhopper is a small, pale green, active insect that sucks the sap from many plants. It injects a toxic saliva into the plant that stunts the plant and causes a cupping of the leaves and a discoloration of the leaf tips in some plants. The leafhopper is killed off by frost in the fall over most of the United States and survives only along the warm Gulf coast. It is borne northward by winds in the spring and arrives in Michigan by early June. There are several generations here each season and the leafhopper can be damaging to such field crops as alfalfa, clover, dry beans, and sugarbeets. The adult leafhoppers fly readily and can move from a hay field that is cut to adjacent fields. Fields should be checked for cupped, discolored leaves and for the leafhopper starting in late June. Be sure to check fields adjacent to hay fields when the hay is cut.

The leafhopper is readily controlled with sprays of insecticides. Unfortunately, leafhopper damage is frequently confused with drought symptoms. Check for the leafhoppers in poorly growing fields to sure that drought is the cause of the poor growth.

Borer

The European cornborer is a cylindrical caterpillar with a definite head, six small legs just behind its head, and ten fleshy legs near its rear. It is light cream to pinkish in color and some larvae have dark spots scattered over their bodies. It is the larvae of the small moth that lays its round, flattened eggs in overlapping "shingles" on the undersurface of the leaves. The larvae that hatch from the eggs feed for a short time on the upper surface of the leaves and then wedge themselves into the whorl or base of the leaves and bore into the stalk. There are two generations per year and it is a pest of many crops. Both generations can be damaging in field corn. Fields should be checked for the eggs on the lower side and the characteristic speckling from feeding on the upper surfaces of corn leaves from the first generation starting in mid-June. A spray or granule should be applied when about three-quarters of the plants have eggs on them or show early feeding injury. The lower sides of the leaves should be checked for eggs of the second generation in August. A spray should be applied to fields that have about one egg mass per plant when the heads of the young larvae are visible as black spots in the eggs. Timing of the sprays for European cornborer control is critical as they must be controlled before they penetrate into the whorl, leaf sheath, or stalk.

Fruit

The tarnished plant bug is a medium sized, oval, active bug that sucks saps from a wide range of plants. It varies in color from green to nearly black. It can be identified by a light colored V-shaped mark in the center of its back. It overwinters as the adult near the bases of plants and other protected places. There are several generations per year and it is a pest of many crops. It increases early in the year in alfalfa and other hay fields and, like the potato leafhopper, moves to adjacent fields when the hay is cut. It injects a toxic saliva into the plants as it feeds. This saliva can cause blasting of flowers, dropping of small pods, and "dimpling" (small, hard, black spots) on the seeds of dry beans. Fields of dry beans, especially those close to hay fields, should be checked for the bugs

when the first flowers appear and again when the pods are small. A spray should be applied when the bugs are easily seen in the field. Damage from the tarnished plant bug is very insidious as it is largely from flowers or pods that are lost and only the "dimpling" of the seeds is actually seen.

Stored Grain Insects

Field crops are not safe from insects even after harvest. There are at least 37 species of insects that attacks stored grains in Michigan. Some of them can fly and are capable of starting an infestation in the field. This is rare, however, and most of our infestations can be traced to old grain, sacks of old seed, spills, and trash within the storage area. A thorough cleaning of the storage area before harvest will eliminate much of the threat of stored grain pests. A sanitary spray of approved insecticide can be used to clear cracks and crevices of insects. The needed repairs to the bin should be made to keep the new grain dry and free of rats and birds. Most of our stored grain pests can increase only in moist or broken grains. Very few of them can reproduce in dry, whole grain. The new grain should be thoroughly cleaned and dried before being put into storage. A grain protectant (a solid insecticide) can be applied to the grain going into storage or a fumigant (a liquid or solid insecticide that changes to a gas) applied after the grain has gone into storage to protect them from insects. Good management that will keep the grains clean and dry is essential to stored pest control. The grain should be checked frequently for signs of the pests. They should be recleaned and dried if necessary and fumigated if insects appear during storage.

SELF-HELP QUESTIONS

Now that you have studied this section, answer the following questions. Write the answers with pencil without referring back to the text. When you are satisfied with your written answers, see if they are correct by checking them with the text. Erase your answer and write in the correct answer if your first answer is wrong. Note that these questions are not necessarily those that are used in the certification examination.

1. What type of soil is most attractive to adult seedcorn maggots?

2. Where are flea beetles most likely to be a problem?

3. When should fields be examined for white grubs?

4. Why is it important to apply insecticides for armyworm control when the worms are small?

5. When should insecticides be applied for spinach leaf miner control?

6. Where does the potato leafhopper overwinter?

7. When should insecticides be applied for European corn borer control?

8. How does tarnished plant bug injure dry beans?

9. What is a grain protectant and when should it be applied?

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